Combined assimilation of hydrography and TOPEX data into an Indian Ocean GCM using the adjoint method

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To study seasonal circulation and meridional heat transport of the Indian Ocean by synthesizing dynamics with data, climatological monthly temperatures and salinities, surface heat and freshwater fluxes, and wind stresses, together with monthly ensembles of three years (93-95) of TOPEX-derived surface geostrophic velocity anomalies, are assimilated into an Indian Ocean GCM. The GCM's adjoint is used to optimally estimate the initial state, monthly surface fluxes, and seasonal heat and salt exchanges with the rest of the World Ocean. Interannual variability is demanded to be small during the optimization.

Impacts of TOPEX data are presented by comparing the estimated meridional and horizontal circulations, meridional heat transport, and thermocline variation resulting from two experiments: one with and one without, assimilating TOPEX data. With TOPEX data, seasonal variations of the meridional overturning and horizontal gyre are strengthed by 6 and 4 Sv (roughly 30 and 15%, respectively). Seasonal variation of the meridional heat transport, is enhanced in the central Indian Ocean by about 0.3 PW (15-30%), but reduced in the southern and northern parts of the Indian Ocean. These impacts are found to be achieved primarily through the modifications in estimated density structure and secondly by changes in estimated wind. When compared with independent observations, the estimated Equatorial Undercurrent and thermocline variation in the southern Indian Ocean are also found to be more realistic with TOPEX data than without. Although the resultant solution of the GCM is overall consistent with the hydrography and TOPEX data in the model interior, inclusion of the TOPEX data results in unrealistic baroclinic flow near the Indonesian Channel, very likely due to the absence of a net mass flux from the Pacific into the Indian Ocean.